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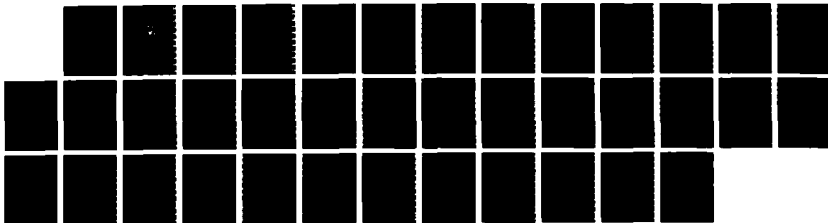
LOSS OF MANUFACTURING SOURCES: AN ANALYSIS OF
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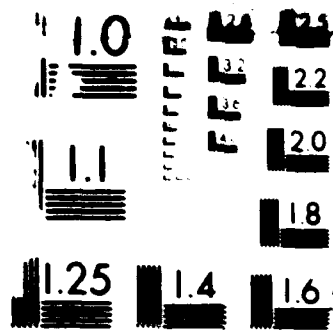
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Monterey, California



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LOSS OF MANUFACTURING SOURCES:
AN ANALYSIS OF ALTERNATIVE SOLUTIONS

by

David V. Lamm

and

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AN ANALYSIS OF ALTERNATIVE SOLUTIONS

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Elizabeth A. Tracy



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ABSTRACT

This study analyzes the situation where the last known manufacturing source for a component announces an intention to cease production, referred to as obsolescence. The report develops a series of solutions categorized into four major areas: (1) source solutions, (2) engineering solutions, (3) system solutions, and (4) stockpile solutions. Each of these categories is arrayed in a decision-making model in an attempt to select the most feasible solutions for further analysis. The key factors in the decision model against which the solutions are analyzed include time, stability of requirement, cost, quantity and technological complexity. The report concludes by demonstrating model utility through a brief case analysis.

Loss of Manufacturing Sources: An Analysis of Alternative Solutions

One of the many problems facing the buyer is associated with the loss of productive and efficient sources of supply. The contracting officer is continually attempting to ensure that viable sources for goods and services exist and hopefully provide sufficient competition to establish a fair and reasonable price. From time to time, the contracting officer for a Government organization or purchasing agent/buyer for a commercial firm is faced with the potential loss of the last available manufacturing source for a particular item. This paper addresses those situations where a contractor or subcontractor has notified a buying organization that they will no longer be a source of supply.

There are several reasons which might cause a company to discontinue production. These include:

- o obsolete technology
- o financial problems
- o uneconomical production rates
- o change in business mix/competition for limited resources within the firm
- o change in profit, growth and investment opportunities

Although not an exhaustive list, these are some of the principal reasons manufacturers are unable or unwilling to continue to supply a part or component. Regardless of the reason, the buying organization must seriously consider options to resolving the sourcing problem. Some solutions are of a short-term nature and

may only be a quick fix while a more permanent solution is pursued. Some solutions will be more attractive than others due to such factors as time, cost, technical complexity and risk. What is needed for the decision-making is a methodology for analyzing the range of feasible solutions available within various constraints and limitations typically found in the case identified here. The research for this article focused on the problems associated with the obsolescence of microelectronic circuits due to the rapid growth and change of semiconductor technology and the subsequent loss of manufacturing sources due to such obsolescence. Although concentrating on a particular technology, the solutions evaluated can be applied to virtually any manufacturing situation, particularly where the technology is maturing at an increasing rate. From time to time throughout this article, the loss of manufacturing sources will be referred to as obsolescence.

Alternative Solutions

Several solutions to the potential loss of a key source might be proposed. These include:

- a. persuade the current source to continue production
- b. identify a new source
- c. develop a new source
- d. purchase from a specialty house
- e. establish in-house production
- f. use a substitute
- g. use emulation

- h. redesign the item
- i. use supply system or stock assets
- j. employ cannibalization
- k. buyout production life-time quantity
- l. buyout until redesign
- m. buyout semi-finished product

A brief discussion of each alternative solution follows:

a. Current Source - the impending disruption of production line processes will not occur if the current producer can be persuaded to continue producing the obsolete component. This alternative involves discovering why the supplier plans to phase out production, and then negotiating an agreement which will motivate the supplier to reconsider plans to cease production.

b. Identify New Source - the nature of component obsolescence generally precludes the existence of other sources since obsolescence occurs when the last remaining supplier ceases production. An attempt to locate other sources may be successful if specifications are relaxed or requirements modified. If a subcontractor is the current source, the search for other subcontractors is facilitated when the prime contractor has originated the component specifications. In this case, the prime contractor is familiar with potential sources and can tailor the contract specifications accordingly. If the Government has provided the specifications, the resolution could be elevated to the governmental level and competition will probably be required.

c. Develop New Source - this is closely related to finding another existing source in the sense that contract modifications may be necessary to attract other producers. The source can be developed by the Government or the prime contractor, though it is assumed that Government funds will be used in either case.

d. Specialty House - several suppliers specialize in out-of-production components. These suppliers generally buy the completed component for resale but may manufacture as well as distribute obsolete parts.

e. In-House Production - in the case of the Federal Government, this would include production at a Government facility, either Government Owned - Government Operated (GOGO) or Government Owned - Contractor Operated (GOCO). If a subcontractor currently produces the component, this would entail commencing in-house production by the prime contractor. In both cases, the decision-making process involves a make versus buy analysis with delivery and quality initially overriding the cost factor.

f. Substitution - an attempt to replace the obsolete component with one which performs the same or similar function.

g. Emulation - the process of producing items which will perform the same function as the discontinued item with the same form and fit. As an example, in producing electronic items, there might be three different methods of emulation. The first concerns the development of a new integrated circuit device that can be mask-programmable to replace the obsolete function in

technologically obsolete devices. A second method involves redesigning and replacing obsolete components on one printed wiring board with a new board containing components with new technologies so that the second board is form, fit and functionally identical to the first. A third type of emulation involves hybrid microcircuit technologies to be used to provide form, fit and function replacement parts.

h. Redesign - involves changing the design of either the obsolete component or the subsystem with which it interfaces to allow the introduction of technology considered more enduring than the obsolete technology. As used here, the term "redesign" will refer only to subsystem redesign, since component redesign essentially resolves the obsolescence problems by introducing a new technology and requires the adaptation of system interfaces to the design.

i. Supply System/Stock - when a system is placed into operation, provisioning and inventory control mechanisms within the supply system ensure that an appropriate number of spare parts will be on hand to support the system during its life. Production requirements are satisfied separately through contractual arrangements with vendors. The supply system/stock alternative involves using supply system or stock assets to support production requirements.

j. Cannibalization - the process of taking components or subsystems needed for production from an existing system with the

intention of using the cannibalized items to prevent production line shutdown.

k. Buyout Production Life-time Quantity - the one-time purchase of enough items to completely support the system for the remainder of the system's life. Frequently referred to as a "life-of-type buy" or simply "buyout," it generally results in buying a sufficient quantity to meet all anticipated production requirements.

l. Buyout Until Redesign - is a "buyout" as defined immediately above but is the purchase of enough items to sustain production until the system is redesigned.

m. Buyout Semi-finished Product - is a "buyout" as defined above but refers to the purchase of semi-finished components with the intention of either finishing production in-house or contracting for final assembly as needed.

For purposes of analysis, these thirteen alternatives have been grouped into four major categories:

I. Source Solutions

- a. current producer
- b. identify a new source
- c. develop a new source
- d. specialty house
- e. in-house production

II. Engineering Solutions

- f. substitution

g. emulation

h. redesign

III. System Solutions

i. supply system/stock

j. cannibalization

IV. Stockpile Solutions

k. buyout production life-time quantity

l. buyout until redesign

m. buyout semi-finished product

Each of these four categories of solutions to the obsolescence problem will be examined regarding the nature of the solutions, key factors and principal advantages and disadvantages.

Source Solutions

One of the first steps a buyer might take is to attempt to persuade the current source to continue production. In exploring this solution, the buyer will want to determine the primary reasons the manufacturer has decided to discontinue production operations. Rather than terminating the entire production process, perhaps the manufacturer can be convinced to partially produce the item and supply this to the buyer for completion. If uneconomical production rates have been experienced, the buyer could explore methods for consolidating requirements within his own organization or together with other organizations in a cooperative purchasing agreement method. The buyer could also explore the feasibility of relaxing certain aspects of

specifications involved, such as reduced in-process testing, less stringent tolerances, greater flexibility in the selection of materials, and different production methods. If technology is evolving rapidly, changes to the product configuration or production methods (both perhaps reflected in the specifications) should be explored on a continuous basis to determine where measures can be taken to avoid obsolete technology. A careful analysis jointly performed by the buyer and the contractor might identify areas where other production operations within the firm can be integrated with production of the item at hand. In most of the solutions identified above, the entire organization of both the buyer and seller will have to be involved in order to achieve a comprehensive solution. Engineering, design, production, purchasing, materials management and top management, at a minimum, will have to become involved in a systems solution.

If, after exploration of all viable avenues for continuation have been exhausted, the current source will not continue as a supplier, the next step is to search for other existing sources. Assistance from the current source might be obtained, particularly if the contractor desires to maintain a good customer-supplier relationship. If the current source is unwilling or unable to participate in the search for another existing source, the buyer might be faced with a sizeable effort, especially if the product involves "mature" or obsolete technology which the industry, in general, has declined to continue. Production using obsolete technology might not appeal

to the majority of potential sources if economic conditions are favorable. They may either refuse to compete for the requirement, or demand monetary compensation not commensurate with the intrinsic worth of the component. These reactions undermine expected benefits of competition, most notably reduced costs and an increased industrial base capability.

Other sources may also be discovered by seeking suppliers who specialize in out-of-production parts or by developing a source of production either commercially or in-house. Leopold has found that suppliers specializing in discontinued microcircuits are experiencing a brisk business.¹ Rochester Electronics, Inc., for example, currently maintains an inventory of over 40 million parts, and Lansdale Transistor and Electronics manufactures and distributes obsolete items. To develop manufacturing capability, Lansdale purchased manufacturing and marketing rights to logic parts which are still used in military systems designed in the 1970s. Purchasing arrangements involve the transfer of the entire mask, assembly, test, burn-in tooling and remaining inventory to Lansdale.² An example of Government in-house production capabilities would be the efforts by the Naval Ocean Systems Center in San Diego to set up a microcircuit production line to duplicate certain types of industry production.

¹Leopold, G., "Shortage of Obsolete Chips Makes It Tough on Military," Electronics, 14 October 1985, p. 43.

²Ibid.

One essential factor pervasive throughout almost all solution categories is the nature or type of technology involved. As a product evolves through the cycle from state-of-the-art to mature to old technology, the number of manufacturers concurrently progresses from many manufacturers producing state-of-the-art components to fewer manufacturers producing mature technology components to virtually no manufacturers producing old technology (only those in business to specialize in old/obsolete technology). Typically, at the time the last known source announces plans to phase out production of a particular component, it is still generally within the "capability" of some manufacturers to produce the component, however they have usually altered resources to accommodate more current technology. The principal problem faced by the contracting officer is not whether existing manufacturers can produce the component, but whether they can be persuaded to produce it.

Motivation of the source to produce will be affected by such factors as the quantity required, duration of production and design stability. B. Sellers claims that "the larger the required quantity and the longer the period that the quantity will be required, the more likely that a manufacturer will accept the commitment to produce the component."³ This is the scenario under which most manufacturers enter into the investment of resources for production purposes. A contracting officer facing

³Sellers, Benjamin, "Second Sourcing, A Way to Enhance Production Competition," Program Manager, May-June 1983, p. 16.

the obsolescence situation, however, has a manufacturer willing to produce a smaller quantity for a shorter duration but for a much higher monetary compensation. This might be acceptable in terms of gaining additional time to explore other alternatives. The assurance that the system and component design will remain stable will be a positive consideration when the manufacturer is making a decision to commence or continue production. If the manufacturer knows the buyer has firm plans to continue producing the system using the component (e.g., a military weapon system) and that the subsystem will also remain unchanged, the manufacturer might feel relatively confident that the requirement is virtually guaranteed on a long-term basis.

Specification problems focus principally on the complexity of the system, component composition and proprietary data rights. The contracting officer will encounter increasing difficulty ensuring that contract specifications are adequate while seeking other sources if the composition of the component or the system with which it interfaces is complex. Modification of requirements could involve extensive and time-consuming investigation prior to implementation; the intention to rely on form, fit and function applications or technical data packages may be overly optimistic if technological "know-how" cannot be successfully transmitted through written documentation; and in-house production capability may not exist or may be too costly to develop if the component is particularly unique. It may not be possible to determine the composition of the obsolete component.

Plans to use competition may be imperiled if the design data package does not exist or is not up to date. The component may also consist of various hybrids, each with unknown individual component compositions. If the design is based upon privately-funded research and development, the developer may be reluctant to release the design. This will cause problems in competing the requirement if the technical data package approach is used. The developer may be willing to release the technical data rights, but at a price the buyer cannot afford or justify.

Such factors as configuration control, test equipment and integrated logistics support will affect the system. Configuration control involves the systematic evaluation, coordination and approval or disapproval of proposed changes to the design and construction of an item whose configuration has been formally approved. When modifying the requirement so that sources will continue production or become willing to commence production, configuration changes will have to be considered. Also, configuration changes may be unintentionally implemented if the winning contractor misinterprets the requirement. Test equipment may be limited in usefulness if modifications to screening requirements and specifications change. To accommodate component modifications, new test equipment may have to be developed and procured. Maracuso states that the product aging cycle creates headaches for logistics managers who maintain military electronics systems. "Since the military demand cycle is often out of sync with the product life cycle . . . the DOD

often needs a chip after it has disappeared from the commercial market."⁴ These headaches will be intensified by modifications intended to encourage other suppliers to compete for the requirement because logistics managers will be responsible for supporting the newly designed system as well as the original system. Lastly, other factors include the availability of a specialty house, in-house production, time and cost. If a component is carried by a specialty house, the most feasible short-term action may be to buy a specified quantity to allow time to consider longer-term solutions. The quantity on hand at the specialty house, as well as the existence of other buyers, must be ascertained in order to know how long the supply will last. If the specialty house doesn't manufacture the item, a warranty might not exist. Further, it may be impossible to determine the reliability of purchased components without testing each one individually. In-house production facilities could be regarded as either short-term or long-term solutions. As a short-term solution, production could be terminated when efforts to redesign the subsystem to accommodate current technology have been completed. As a long-term solution, the use of Government-funded production facilities will impede the components' inevitable decline into obsolescence. Since this alternative is usually costly and ensures a permanent supply of certain obsolete components, the contracting officer must ensure that the design

⁴Maracuso, E., "Department of Defense Vexes Integrated Circuit Manufacturers," Military/Space Electronics Design, April 1985, p. 51.

is stable and that the components will be needed in sufficient quantity and for a long enough period of time to justify expense and use of the facilities for this particular purpose. The time period between notification and actual production shutdown will influence the method used to search for other sources as well as the decision to use in-house production capabilities. It may be possible to convince the source to extend the time period until alternatives can be fully investigated. Alternatives which take the least amount of time are continuation with the same source at an increased price and a search for other sources. If the original source agrees to continue production, negotiation of additional compensation could be accomplished quickly. If modifications to screening requirements are involved, lengthy research and configuration approval processes may be involved. The prime contractor's search for other sources will proceed more quickly than a governmental search because the prime contractor can rely upon knowledge of the industry and pre-established relationships with potential sources whereas the Government is restricted to sealed bidding or competitive proposal procedures. The in-house production alternative may be the most time-consuming since feasibility research and the modification or construction of production facilities must be accomplished.

Consideration of costs to be incurred as a result of the source selection decisions depend to a large extent upon the nature of the particular alternative and the combination of actions required. For example, continuation with the same source

may simply involve additional monetary incentive, or it could involve costs associated with modifications necessary to influence the vendor to continue production. Modification costs will include charges to test equipment which may have to be redesigned to accommodate the component modifications, the cost of publication changes to document configuration changes, and recurring and nonrecurring costs associated with the actual modification. Qualification costs are usually necessary when another source is selected, and nonrecurring costs as well as qualification costs are involved with developing a new source, especially if the new source designs the required component. Use of competition may require the procurement of proprietary data rights, and the costs of in-house production capability could range from modification of existing facilities to complete construction of new facilities.

Engineering Solutions

Analysts seeking a solution to the obsolescence problem want to cause as little disruption to the affected system as possible. The thought process involved in an analysis of engineering solutions progresses from changes which least affect system configuration to those which have the greatest configuration impact. Methods of resolving obsolescence having the least affect on configuration include substitution and emulation. Engineering personnel interviewed for this study indicated that the first engineering reaction to an obsolescence problem is to investigate possible component substitutes. If no acceptable

substitute is available, emulation might be considered but historically has not achieved any degree of success. The last of the solutions in this category is redesign to accommodate newer technology which will affect configuration and will generally require formal approval. Accounting for configuration changes is accomplished through the Engineering Change Proposal (ECP) process. ECPs are generally categorized as Class I, which have an effect on the functional configuration, product configuration or technical requirements of the item, or Class II, which do not have a major effect on configuration, such as the correction of document errors or addition of clarifying notes. Class II changes should be pursued first, however any amount of redesigning will usually require a Class I change.

Many of the same factors explored earlier as Source Solutions are involved in engineering solutions as well. When analysis of various available alternatives commences, one source still exists and other sources have just recently phased out production of the affected component's technology to concentrate on state-of-the-art pursuits. Interviewees in this study indicated that the existence of one remaining source and the fairly recent participation of other sources in the production of the obsolete technology provides more opportunities to identify substitutes or to develop emulation capabilities than if very old technology were involved. The availability of substitutes will depend upon the complexity of the system and component composition. The more complex the system or varied the component

composition, the more likely that a substitute will not be found to match the required function, or emulation will not be technologically possible since there will be too many design and performance variables. It may be necessary to purchase proprietary data rights to determine the actual component composition. Emulation will prove particularly costly and time-consuming if techniques must be developed for individual applications.

Redesign of the system to accommodate new technology should be the last alternative selected after attempts to find substitutes have failed and emulation has been determined technologically or economically not feasible. Redesign is time-consuming, costly and affects system configuration. Before deciding to redesign, long-range system plans such as quantities required, duration of production, and design stability must be considered. If the system design is stable and expected to be in production for the foreseeable future, if substitutes are not available, and if emulation is not feasible, redesign may then be the only option which will assure continuation of the system. The time available before production shutdown will influence the amount of research effort which can be accomplished. A check for the availability of substitutes can be performed fairly quickly compared to the time to emulate or redesign the component or subsystem. Cost will depend upon the alternative chosen and the combination of actions required. In general, substitution will be the least costly since the substituted component will

interface with the same subsystem as the obsolete component, and redesign of the subsystem will be the most expensive since interfaces and publication changes are affected. The cost of emulation varies with the chosen application and availability of techniques, however, emulation through redesign is considered too costly to serve as a source of discontinued parts.

When faced with an impending obsolescence problem and a very short time frame within which to react, the options of using supply system or stock assets or cannibalization may appear attractive. If the situation is so urgent that virtually no time exists to explore other alternatives and the production line is in imminent danger of shutting down without the required component, there is justification for investigating the use of these two alternatives. Interviewees stressed that these solutions do not solve the problem satisfactorily and are useful only as short-term alternatives until thorough analysis can be performed to determine a more permanent solution.

From a timing standpoint, if there is a distinct possibility that the production line will be halted or severely constrained without the component, locating and acquiring a sufficient quantity from stock or from operating systems may be the fastest method to prevent this occurrence. Use of system stocks may be opposed by inventory managers who will want to analyze the effect of reduced stock levels on projected operational support requirements. Cannibalization generally occurs within the same organizational unit's assets. Locating systems to cannibalize

may result in consideration of inoperable units placed in long-term storage or "downed" units awaiting more extensive work to return them to operational status. Cannibalization and use of supply system/stock assets are not normally undertaken to satisfy production requirements, hence formal procedures for these actions generally do not exist.

Stockpile Solutions

The life-of-type buy is generally pursued when other more economical alternatives to a material shortage or manufacturing phase-out have been completely explored. Quantities to purchase are difficult to estimate for such reasons as the lack of comprehensive end item application data and the difficulty in predicting equipment life. To avoid the overhead added to buyout quantities, the Government may decide to break out the component, buy out the manufacturer and supply the component as Government Furnished Equipment (GFE). This action eliminates Government reliance upon the prime contractor to manage the routine elements of providing production support components, but generates storage and warranty problems for the Government. For example, the GFE must be provided to the prime contractor in acceptable condition. Because components may be stored for several years prior to production use, the inventory will be subject to the problems of deterioration and damage. Special problems, such as a controlled environment for the storage of microcircuits, may be encountered. Experience has shown that many manufacturers give six to nine months notice when component production will be discontinued.

Research to determine an appropriate means of support, including cost analysis, cannot always be accomplished within this time frame. The prime contractor might analyze the situation and make recommendations to the Government. If the Government's internal coordinating efforts are not completed in time to provide a decision before the buyout date, the prime contractor will probably take action to protect the production line by buying estimated quantities required for projected production requirements and then seek reimbursement from the Government. Usually the prime contractor will plan for reimbursement in subsequent contract work, however, a change in requirements may leave the prime with excess quantities on hand.

Buyout is used to procure enough components to last the life of the system or to sustain production until redesign can be accomplished. Key factors to consider are system stability (including design, duration of production and quantity), material considerations (shelf-life, storage and proprietary data rights) and time/cost considerations.

Stability of design and duration of production refer to the length of time the existing design is expected to be used and the time period over which the system utilizing the affected component is to be produced. The objective of the buyout alternative is to provide the required number of components for the time period needed. Plans to redesign the subsystem or replace the component with a new design will affect the amount of time the buyout quantity will be useful, as well as the planned

length of production for the system. The determination of an accurate buyout quantity will depend upon the period of time over which the components will be used. Estimating quantities for a life-time buyout will be hindered by the lack of firm plans to continue producing the system beyond current projections. Even when it is possible to attain a reasonable estimate of required quantities, the manufacturer may be unwilling to produce the exact amount needed due to lot size requirements or a perceived uneconomical production run.

If the component is considered complex, system designers may be influenced to buy a life-time supply rather than disrupt the component and subsystem designs with increasingly intricate changes. Complexity will also affect quantity estimates, perhaps requiring that a greater percentage of expected nonworking components be included in the estimates. Buying a sufficient quantity of material to last for the estimated production period may necessitate storing the components or unpackaged devices for an extensive period of time. The length of time these components can be expected to remain operable, as well as the need for a controlled storage environment must be considered. The storage of unpackaged devices may require establishment of a contract for periodic assembly and delivery. Knowledge of the component's composition will assist in the determination of shelf-life and storage considerations. Purchase of proprietary data rights may be necessary to discover component composition.

The amount of time available to decide upon a course of action will influence the analysis to determine whether buyout until redesign, life-time buy or the purchase of semi-finished components is the most feasible approach. Time will also affect the accuracy of quantity estimates. If the prime contractor makes the lifetime buy through subcontractor tiers, the cost will include component unit costs plus added overhead and profit at each tier. Other costs include storage, purchase of too many components due to mandated production lot sizes, and the price of warranties and proprietary data right. The purchase of semi-finished goods will require subsequent manufacturing and assembly cost.

Advantages and Disadvantages of Solution Categories

Each of the four categories of solutions have both positive and negative aspects attendant to their use. Figure 1 summarizes the principal advantages and disadvantages of each.

Figure 1

Advantages and Disadvantages
of Obsolescence Solutions

	Source Solutions	Engineering Solutions	System Solutions	Stockpile Solutions
Advantages	1. Continue same/ slightly modified tech- nology 2. Allow time to pre- pare for long-term solution	1. Continue existing subsystem configuration with substitution or emulation solutions 2. Redesign using more current technology	1. Immediate access to urgently required components 2. Production continues while investigating longer-term solution	1. Expedient procurement of sufficient items to avoid production shut- down 2. Continue same configu- ration
Disadvantages	1. Cost of convincing current source to con- tinue 2. Nonrecurring costs and qualification expense of obtaining new source 3. Availability/cost of proprietary data 4. Specification problems (component composition, outdated/ nonexistent data package 5. Intentional/uninten- tional configuration changes	1. Costs of emulation or redesign 2. Configuration changes to component or subsystem 3. Time required to emulate/redesign may affect production continuity	1. Short-term solutions which do not resolve basic obsolescence problem 2. Negative effect on supply support 3. Negative effect on operational ability/ readiness due to cannibalization	1. Difficulty in esti- mating exact quantities needed for future pro- duction 2. GFE storage and warranty problems 3. Prime contractor buy- out before Government authorization 4. Obtaining relief from GFE warranty when prime buys out vendor

Decision Analysis Model

Four categories of potential solutions together with key factors and considerations have been presented. Within each category, one can examine and accept or reject alternative solutions in a logical sequence moving from least disrupt options to those which require progressively significant adjustment to procedures or configuration. Figure 2 presents the four categories of solutions together with the sequence of "easier" to "more difficult" solutions.

Figure 2

Sequence of Solutions Alternatives

Source Solutions	Engineering Solutions	System Solutions	Stockpile Solutions
1. Original producer	1. Substitute	1. Supply system	1. Buyout production Life-Time Quantity
2. Find another source	2. Emulate	2. Cannibalize	2. Buyout until redesign
3. Develop new source	3. Redesign		3. Buy semi-finished items
4. Specialty house			
5. In-House production			

The use of "within category" alternative analysis may result in the selection of one or more feasible solutions from each category. A decision model is needed, however, to provide a method for making "between categories" selection. Five principal factors directly influence the choice of an alternative both within and between each category: (1) time, (2) stability, (3)

cost, (4) quantity, and (5) complexity. The subsequent analysis incorporates these five factors with all of the considerations discussed under the four solution categories. The decision model in Figure 3 arrays these five factors against the 13 alternative solutions identified earlier. For simplicity, each of the five factors is viewed from a two-dimensional perspective, e.g., time is either short or long, cost is either low or high. A weighting scheme using non-quantitative elements is employed. The (+) weight indicates that the alternative should be chosen if the particular factor characteristic exists and the (-) indicates the alternative should not be chosen if the characteristic exists. The (0) implies that the alternative is neutral with regard to selection, i.e., it could either be chosen or not chosen as determined by the decision-maker. The decision model combines the five factors and the alternatives into a matrix in which each alternative can be assessed based upon the (+), (-) and (0) weightings.

In order to use the decision model (Figure 3), the circumstances of a particular example will be examined. In this case, the last known source plans to cease production in two months, there are no plans to replace the component or to redesign the system, the component is not considered complex, required quantities are substantial, and funding is not available. This case suggests the following characteristics: short time, stable, low cost, not complex and large quantity. There are three steps for progressively narrowing the range of

available alternatives when considering a particular situation. First, the (+), (-) and (0) weights from Figure 3 for each alternative are summarized in the far right column of the model. Figure 4 shows the results of this procedure for the characteristics of the example. Alternatives with any (-) indicators are excluded from further consideration because they cannot favorably satisfy analysis generated through combined assessment of the five factors. In this example, the (-) alternatives, "Government find another source," "develop new source," "in-house production," "emulate," "redesign," "buyout production life-time quantity," and "buy semi-finished product" will not fit the short time period allowed for analysis and implementation. "Cannibalization" and using "supply system" assets are not considered permanent solutions, and "buyout until redesign" is not a rational decision because there are no plans to redesign the system. Alternatives with (+) and (0) indicators include "original producer," "contractor find another source," "specialty house," and "substitute."

The second step involves determining which (+) and (0) alternative is most appropriate by considering the relative importance of particular factors. For example, if time is considered more important than the other four factors, there may be some alternatives with (0) indicators in the short time column which would be considered less desirable than those with (+) indicators. In this example, all alternatives originally

FIGURE 3

ALTERNATIVES WEIGHTED IN RELATION TO APPLICABLE FACTORS

	TIME		STABILITY		COST		QUANTITY		COMPLEXITY	
	Short	Long	Stable	Not Stable	Low	High	Small	Large	Not Cpx.	Complex
Original Producer	+	0	+	+	+	-	+	+	+	+
Contractor Find Another Source	+	0	+	-	+	+	0	+	+	0
Government Find Another Source	-	+	+	-	0	+	-	+	+	0
Develop New Source	-	+	+	-	-	+	-	+	+	0
Specialty House	+	0	+	-	+	-	+	0	+	+
In-House Production	-	+	+	-	-	+	-	+	+	0
Substitute	+	0	+	-	+	-	0	+	+	+
Emulate	-	+	+	-	-	+	-	+	+	0
Redesign	-	+	N/A	N/A	-	+	-	+	0	+
Supply System	+	-	-	+	+	-	+	-	+	0
Cannibalize	+	-	-	+	+	-	+	-	+	0
Buy Out Production Life-time Quantity	+	0	+	-	-	+	-	+	0	+
Buy Out Until Redesign	+	0	-	+	+	0	+	0	0	+
Buy Semi-Finished Product	0	+	+	-	+	0	-	+	+	0

selected because of their total of five (+) and (0) indicators have (+) indicators in the short time column, and no further elimination can be made by examining the most significant factor.

The third step for narrowing the range of alternatives involves examination of the "within category" selection process. The first three alternatives with (+) and (0) indicators are "original producer," "contractor find another source", and "specialty house," each from the Source Solutions category. Following the order of consideration previously explained, an effort should first be made to determine if the original producer can be persuaded to continue production. If not, then the prime contractor should attempt to locate another source, and, lastly, the availability of a specialty house should be assessed. Concurrent with this decision process, the feasibility of the fourth alternative, "substitution" from the Engineering Solutions category, can be explored.

FIGURE 4

DECISION PROCESS ILLUSTRATING THE SELECTION OF APPROPRIATE ALTERNATIVES

	TIME		STABILITY		COST		QUANTITY		COMPLEXITY		SUMMARY	
	Short	Long	Stb.	Not Stb.	Low	High	Small	Large	Not Cpx.	Cpx.		
Original Producer	+	0	+	+	+	-	+	+	+	+	5(+)	•
Contractor Find Another Source	+	0	+	-	+	+	0	+	+	0	4(+)	1(0) •
Government Find Another Source	-	+	+	-	0	+	-	+	+	0	2(+) 1(0)	2(-)
Develop New Source	-	+	+	-	-	+	-	+	+	0	2(+) 3(-)	
Specialty House	+	0	+	-	+	-	+	0	+	+	5(+)	•
In-House Production	-	+	+	-	-	+	-	+	+	0	2(+) 3(-)	
Substitute	+	0	+	-	+	-	0	+	+	+	4(+)	1(0) •
Emulate	-	+	+	-	-	+	-	+	+	0	2(+) 3(-)	
Redesign	-	+	N/A	N/A	-	+	-	+	0	+	3(-)	1(0)
Supply System	+	-	-	+	+	-	+	-	+	0	4(+)	1(-)
Cannibalize	+	-	-	+	+	-	+	-	+	0	4(+)	1(-)
Buy Out Production Life-time Quantity	+	0	+	-	-	+	-	+	0	+	2(+) 1(0)	2(-)
Buy Out Until Redesign	+	0	-	+	+	0	+	0	0	+	3(+) 1(0)	1(-)
Buy Semi-Finished Product	0	+	+	-	+	0	-	+	+	0	3(+) 1(0)	1(-)

The ability to select one of these alternatives depends upon the willingness of the original supplier to continue production, and the actual availability of another source, a specialty house, or a substitutable item. If more than one of these alternatives is possible, consideration must be given to circumstances peculiarly unique to the situation and to the conditions inherent in each alternative. For example, the original producer may be willing to continue production for only a short time. Since the component will be needed for a much longer period, selection of a substitute might be a better long-term choice. Perhaps the prime contractor has found another source, but will have to make configuration changes to interest the source in producing the item. In this case, the intricacies of configuration changes must be weighed against implementation implications of the other possible alternatives. Use of the model assists in narrowing the range of available alternatives to those most suited to the particular circumstances. However, judgment is still required to make the final selection. There are too many variables to permit final alternative selection to be made entirely by the model.

Conclusion

The decision model presented in this article provides a method for analyzing and selecting alternatives to obsolescence. The assignment of weights to each factor is a subjective process and can be altered on the basis of different analysis. The choice of alternatives is guided to a significant extent by a combination of circumstances surrounding each particular

situation. The model condenses the circumstances into five factors on a two-dimensional basis, arrays the alternatives from all four solution categories, and weights the alternatives in relation to each factor characteristic. The assignment of weights enables the decision-maker to assess the overall applicability of each alternative to specific obsolescence situations. The model then allows consideration of the relative importance of each factor to particular obsolescence situations, and enables the identification of the most feasible alternatives in light of combined circumstances.

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